Electric Farms

The role of farms as future power stations

Rewiring Aotearoa

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Introduction

For decades farming has played a significant role in New Zealand's economy. As the transition to a low emissions world begins to accelerate, the global economy is becoming more competitive, and the cost of farming and doing business are increasing. We grow global commodity products in a high-wage economy, so in order to remain competitive we must leverage our country's advantages. Electrifying our farms presents a real opportunity for farms and rural communities to reduce their costs and play a significant role in New Zealand's energy transition.

Farmers are always looking for ways to run better businesses and help their communities. As it stands, we could make more money for the primary sector, keep the cost of delivered energy low for those in our regions and create thousands of rural jobs.

As farmers, we can immediately save on energy costs by electrifying the dozens of fossil fuel machines we use every day. We could also create new revenue streams and invest in our resilience by installing solar panels on unproductive land, on roof space of large sheds and floating on surface water of large irrigation dams. The ability to store large amounts of electricity on our farms in batteries also drastically increases our resilience and operational efficiency, and puts us in a unique position to defer and negate the need to invest in more poles and wires in our area. By exporting electricity to the grid, farmers could make a significant contribution to the country's predicted 2-3 times increase in renewable electricity demand.

In the current landscape, the focus of energy system planning tends to be on building large power stations (or grid-scale renewable energy solutions) and, to a lesser extent, residential solar and battery installations. But, medium-scale solutions farmers could offer deserve considerably more attention. Farmers are not generally burdened with cumbersome consenting processes and solar installations on farms are much less likely to have adverse effects on the existing environment or biodiversity.

Farmers produce the most they can from the inputs they have. Typically, that's been food or fibre, but there is something else that New Zealanders need that farmers are in a great position to produce: renewable electricity.

Farms are usually owner-operated and have the space and access to sunlight that positions them perfectly to provide mid-scale renewable electricity solutions (100kW to 10MW of generation and 100kWh to 5MWh of storage). With the right systems in place, farms can invest in these assets to save money and add an additional revenue stream by producing and storing solar power and timing export perfectly for when it is most valuable.

The transition to a net zero energy sector is already underway. The choices we make now and in the coming years will shape the future of our country. If done well, the investments we make to enable this transition will improve productivity, energy security, resilience, intergenerational fairness, regional growth and employment opportunities for everyday New Zealanders.

The number eight wire mentality is part of our national mythology. Early generations of farmers had to learn to be self-sufficient and make the most of the resources they had around them. And what farmers have around them now is plenty of land, lots of sun, increasing demand for renewable electricity and a need to save money and diversify their revenue streams. Using, creating and storing more electricity on New Zealand's farms is in everyone's economic and environmental interests, so there's a real opportunity to take a leaf out of Bill Gallagher's book and make that number eight wire electric.

The future will require more energy

In their report *The future is electric*[1], Boston Consulting Group reported that meeting the growth in electricity demand over the 2020s will require $42 billion of investment. This includes $10 billion in new large-scale generation, $8 billion in transmission and a stunning $22 billion worth of distribution infrastructure. *Transpower's*[2] recent modelling suggests a 68% increase in electricity demand by 2050, with an additional 5GW of generation required at a similar level of investment, including 70 new grid-scale connections. In line with this, the *Ministry of Business, Innovation and Employment (MBIE)*[3] has said that uptake of EVs will drive demand growth in the coming decades. As the population grows and more and more machines are electrified, the pressure being placed on our electricity network is growing.

The 10 May Transpower warning of a potential shortage in generation shows that these pressures are already being felt. For New Zealand, how the growing demand for electricity will be met is an important strategic question. Almost all recent energy system modelling for New Zealand assumes that grid-based electricity will be lower cost than customer-generated energy (primarily solar). As a result, the models conclude that the vast majority of the increased electricity demand from homes and businesses should be met from grid-based electricity. But these energy system models have *consistently underestimated*[4] the speed at which the cost of solar and batteries will reduce, as well as the rapid uptake of these technologies by homeowners and farmers.

Rewiring Aotearoa's recent *Electric Homes*[5] report has shown that, due to the plummeting cost of solar and batteries, and New Zealand having some of the world's most expensive fossil fuel prices, we are one of the first countries in the world to reach what's called the electrification tipping point. That means it is now cheaper to buy electric machines and run them with a combination of rooftop solar, home batteries and our highly renewable grid than it is to buy and use fossil fuel equivalents, even when you include the upfront costs and cost of finance.

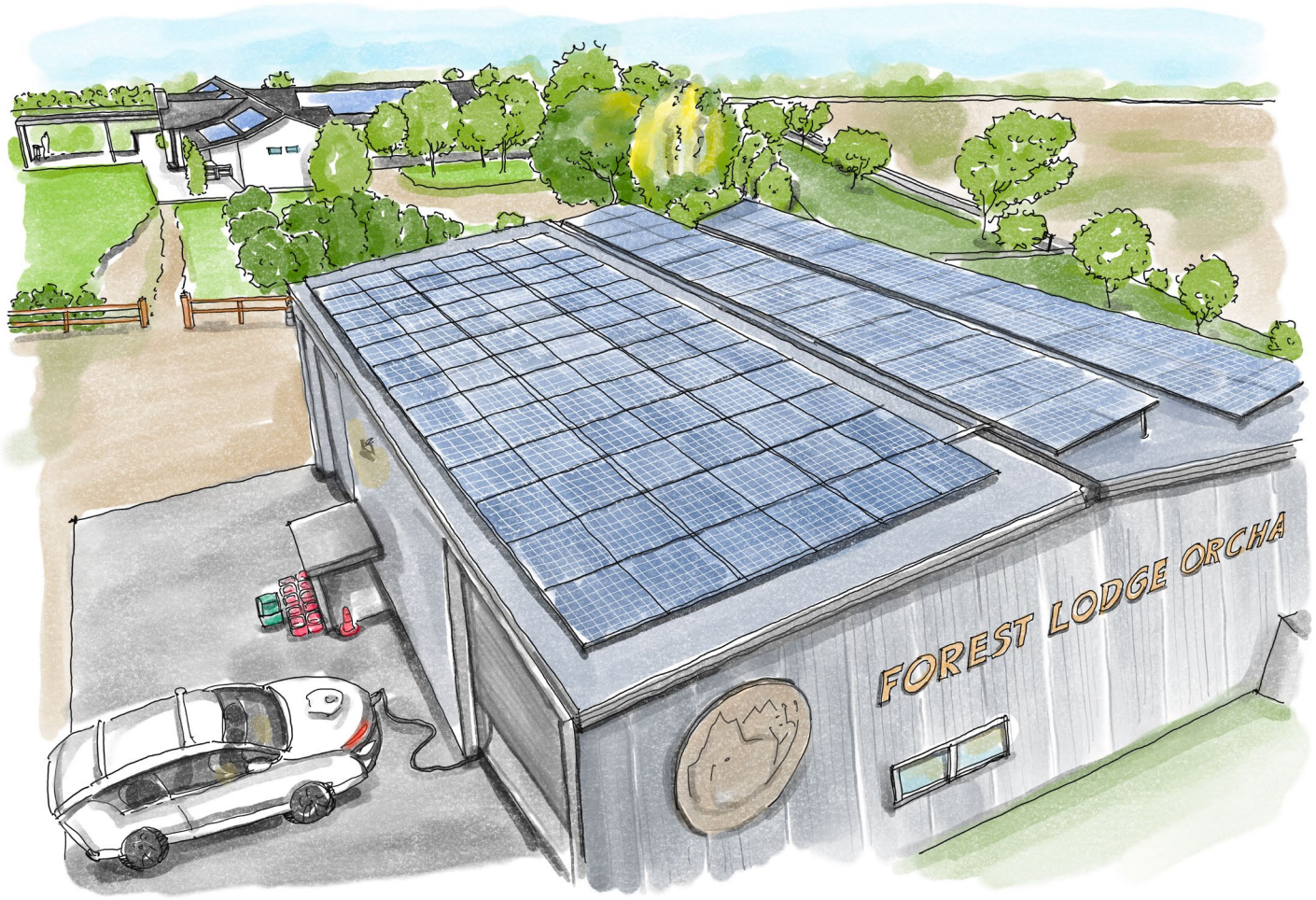
Our farmers are in a unique position to capitalise on this because we have greater buying power than individual households; we have the land and space to install much larger systems; we are usually owner-operators who can make our own decisions and in most cases there are no split incentive issues between tenants and landlords, as is often the case in urban households or commercial property; and, importantly, we often have access to finance and are generally well-placed to take on long term investments, especially those that will save us money.

Farms are also usually very close to medium voltage networks, meaning they can scale up renewable systems without physical constraints or undue overloading risks to the distribution networks.

As customer energy resources (CER) such as solar and batteries *continue to come down in price*,[6] and large-scale infrastructure continues to increase in price, the case for enhanced focus on CER has never been stronger. Although New Zealand's electricity grid is already about 80% renewable *(82% in 2021)*,[7] electricity is only about 26% of the country's total energy consumption and we

1. https://web-assets.bcg.com/b3/79/19665b7f40c8ba52d5b372cf7e6c/the-future-is-electric-full-report-october-2022.pdf
2. https://static.transpower.co.nz/public/publications/resources/TP%20Whakamana%20i%20Te%20Mauri%20Hiko.pdf?VersionId=FljQmfxCk6MZ9mIvpNws63xFEBX-whX7f
3. https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-publications-and-technical-papers/energy-in-new-zealand/energy-in-new-zealand-2023/electricity/#:~:text=Electricity%20demand%20has%20increased%20steadily,463%20gigawatt%2Dhours%20in%202022.
4. https://www.cell.com/joule/fulltext/S2542-4351(22)00410-X
5. https://www.rewiring.nz/electric-homes-report
6. https://thespinoff.co.nz/partner/28-01-2022/how-the-suns-power-is-changing-our-electricity-market
7. https://www.mbie.govt.nz/dmsdocument/23550-energy-in-new-zealand-2022-pdf

need to at least double, if not triple our electricity use to electrify and replace the fossil energy in our economy. *The Government has already signalled the need to reduce our reliance on fossil fuels through their commitment at COP28 to triple renewable energy by 2030. CER provides lower delivered energy costs than large-scale generation,*[1] doesn't suffer from line losses, doesn't require long and costly consents, and adds enormous resilience to the electricity grid. The cheapest way to meet our COP28 goal includes the expansion of rooftop solar and batteries.



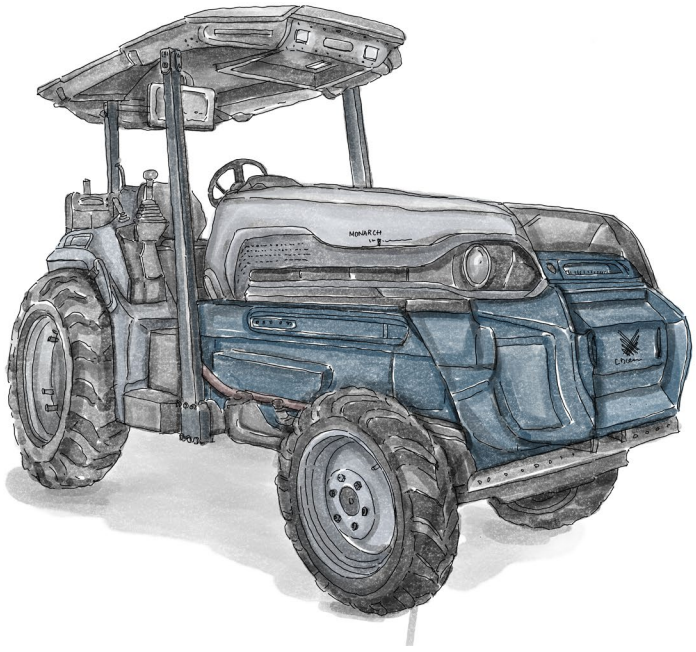
1. https://www.beehive.govt.nz/speech/cop28-national-statement-new-zealand#:~:text=Harness%20our%20trade%20and%20economic,longer%20rely%20on%20fossil%20fuels.

The opportunity for farms and rural communities

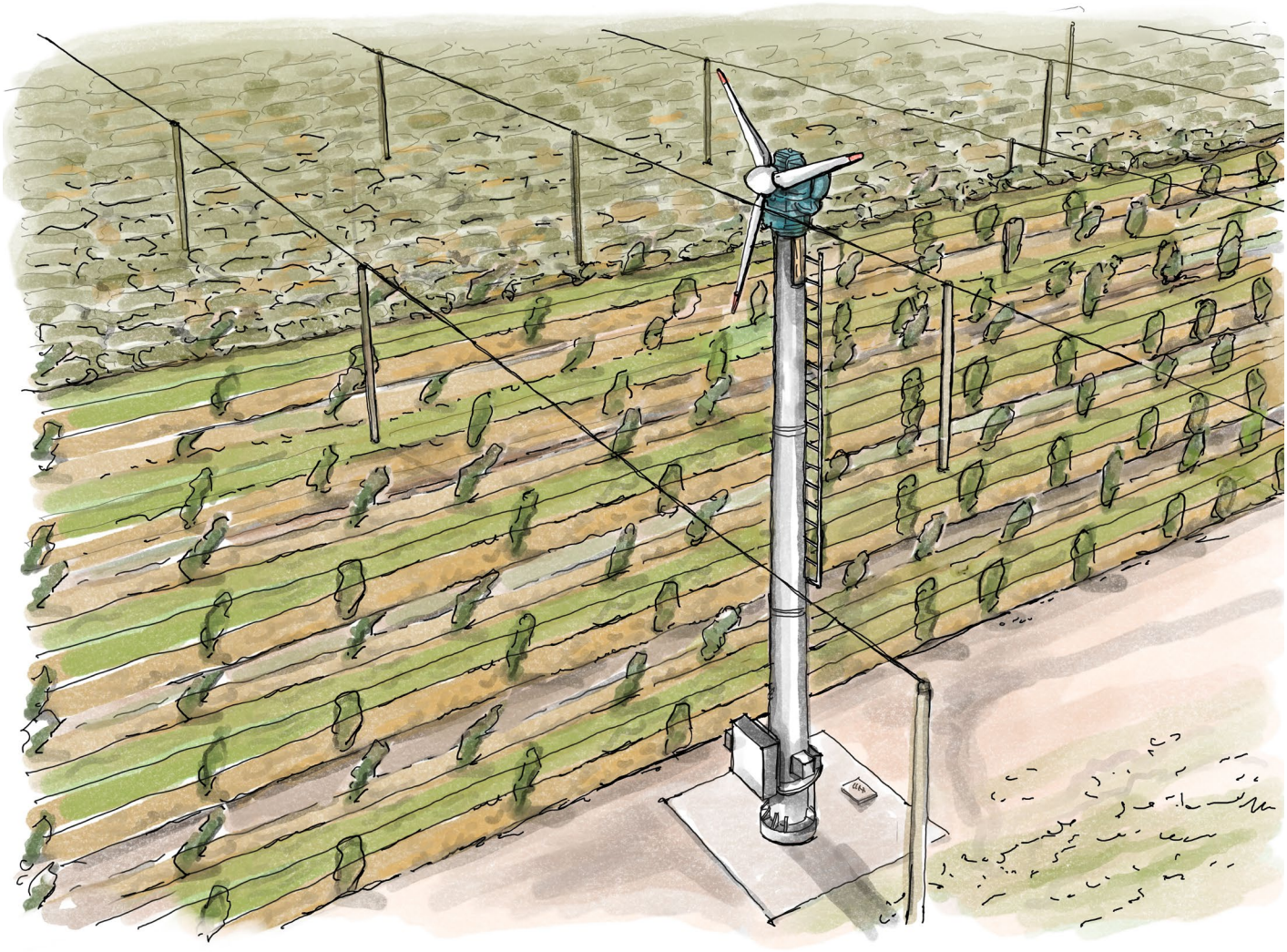
Farms are uniquely positioned to champion the use of CER because they are both businesses and homes. But, they are currently heavily reliant on fossil fuels. R*esearch from the Energy Efficiency and Conservation Authority (EECA)*[1] has found that the agriculture sector spends around $700 million on diesel each year. Shifting away from diesel machines is a huge economic opportunity for farms. Electric machines provide cheaper to run, lower-emissions alternatives to traditional diesel or oil-powered equipment. When powered by CER such as solar and batteries, farms can dramatically reduce their energy bills and cut their energy emissions to near-zero.

It's important to note that electric equivalents for some machines on farm - namely large tractors, harvesters and other mobile machinery - do not yet exist. But by setting up farms to become power plants, we make the integration of this technology easy when it does become financially viable for our farmers to electrify large machines. In the future we envisage combine harvesters with 1MWh batteries *(an Australian company is already working on this)*.[2] The batteries on these machines could be leveraged further by backing up the farm's energy and our country's national grid when it is sitting idle for the majority of the year.

At *Forest Lodge Orchard*[3] in Central Otago, we have installed 45kW of solar panels on our rooftops and 120kWh of batteries to power our home and farm. We have also electrified all of our on-farm machinery, including two electric frost-fighting fans, electric golf carts and New Zealand's first electric tractor. Rooftop solar and a battery bank provides about 45% of the farm's electricity needs, so although our electricity use has increased by about 900% and we require a lot more electricity from the grid than the previous farmer, the peak drawdown from the grid has remained low.
No more local distribution infrastructure has been required to electrify Forest Lodge Orchard and no new poles and lines needed to be built, despite the massive increase in electricity use.



1. https://www.eeca.govt.nz/assets/EECA-Resources/Research-papers-guides/Off-road-liquid-fuel-insights.pdf
2. https://linttas.com/
3. https://www.forestlodge.nz/



Our local distribution networks are currently built to handle peak spikes in electricity usage. We are not aware of any of New Zealand's distribution companies routinely tracking utilisation, but we understand that in many circumstances, the utilisation rates are as low as 30-40%. This means we can double the amount of energy flowing through our local poles and wires provided we smooth out the peak spikes in electricity use. One way to achieve this is to encourage electricity users to consume energy in off-peak times, and the other way to do this is to reward farmers who export during peak periods to bring those peak spikes down. As an example, Forest Lodge Orchard can export over 100kW back to the grid, which is enough to offset the peak demand of 25 local homes.

As the *Electric Homes*[1] report demonstrates, in terms of delivered electricity costs, rooftop solar is by far the cheapest option for New Zealanders on farms or at home (see Figure 1 below). As of early 2024, New Zealand homeowners currently pay around 12c/kWh for transmission and distribution lines. This figure is likely to increase in the future if more large-scale generation is built. Forest Lodge shows how CER enables us to dramatically increase our electricity use without requiring any additional investment in transmission and distribution. The pressure that widespread investment in CER can take off large-scale infrastructure - as well as household and business energy bills - is hugely beneficial.

1. https://www.rewiring.nz/electric-homes-report

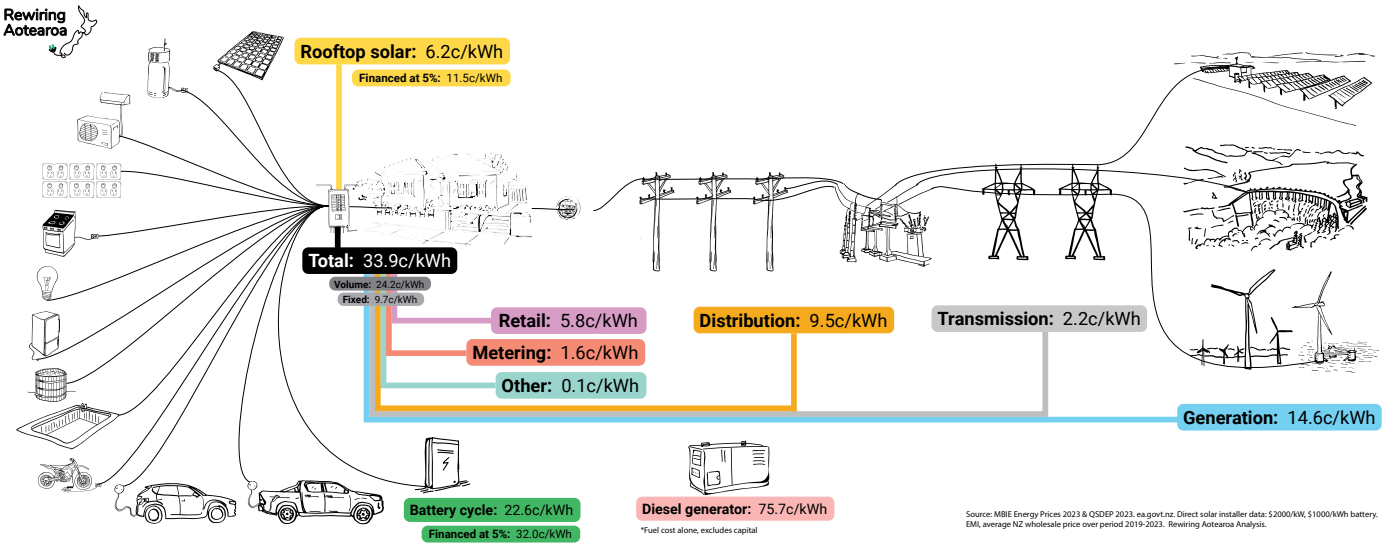


Figure 1. Delivered electricity costs breakdown for grid electricity, rooftop solar, battery cycles and diesel generators.

Cost savings on-farm

Forest Lodge Orchard is making cost savings that can be realised by all farms. After electrification, we save over $40,000 a year across the farm and home from avoided costs of diesel, avoided costs of grid electricity and avoided electricity network lines charges. As Figure 2 shows, all of the machines run on the farm are cheaper to operate since electrification, and cheaper still with the addition of solar and batteries. For example, diesel frost fans burn large amounts of fuel and can cost almost $10,000 a year to run based on our frost hours, whereas our two 30kW electric frost fans are more efficient at 20% the operational cost. Similarly, the 40hp electric tractor does the job of a 80hp diesel equivalent thanks to the benefits of electric power and instant torque, and costs a fraction of the price to run. This also includes savings of over $10,000 in our home from converting the diesel underfloor heating and gas water heating to electric.

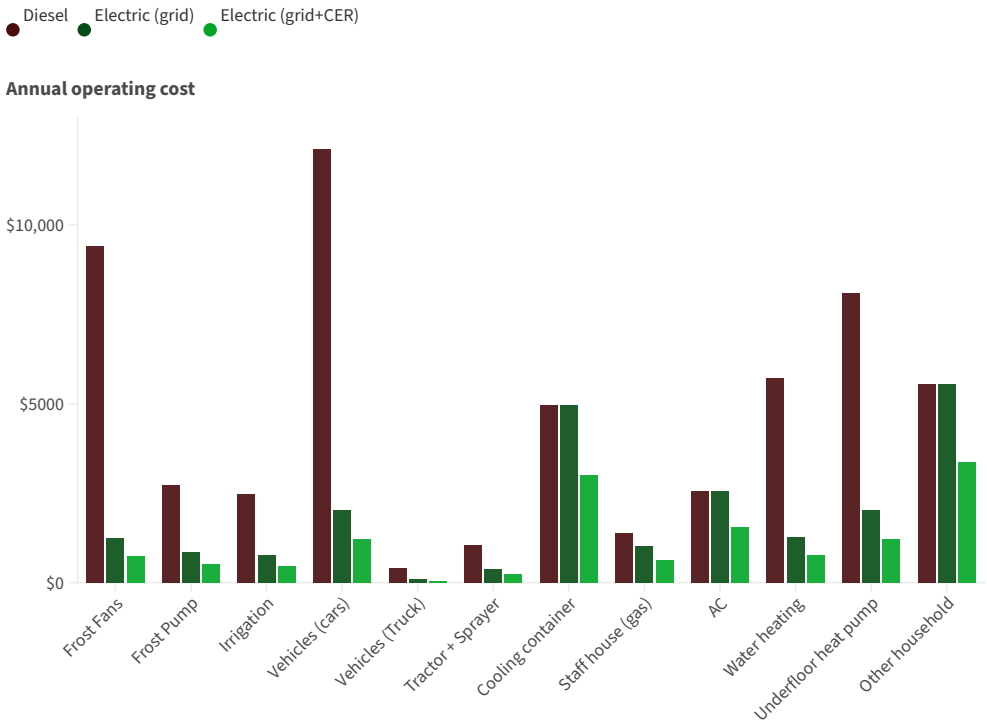


Figure 2. Annual operating costs of machines at Forest Lodge Orchard including estimates of costs of diesel alternatives and if electric machines were powered only by the grid.

Those living in rural areas also drive a lot further than the average New Zealander, so the economics get even better for farmers with electric vehicles that can be charged with cheap rooftop solar. Running two equivalent petrol vehicles at our current mileage would cost around $12,000 a year. After electrification and CER, the orchard spends just over $1000 a year.

It's not just about saving money, either. Through electrification and investment in CER we have also cut our energy emissions from around 54 t CO^2e per year to around 4 t CO^2e, a massive 93% reduction. With a fully renewable electricity grid, the orchard could be a zero energy emissions operation. And because consumers have shown a willingness to pay more for more sustainably produced goods, our cherries have also been able to fetch a premium in the domestic market.

Low-cost finance can support this transition

In total, Forest Lodge Orchard invested $881,590 on electric machinery and $272,604 on the solar and battery system. $141,228 of this, for the frost fans, tractor and sprayer, was supported by demonstration grants from EECA and innovation grants through the Sustainable Food and Fibre Futures fund administered by the Ministry for Primary Industries. Purchase of the vehicles was supported by the now discontinued EV rebate scheme. The total cost was about $450,000 more than conventional (diesel) alternatives. For many farmers, this initial outlay is too high. But, unlike fossil fuels, where prices rise with inflation and can often rise sharply due to other macro-economic reasons, solar and batteries essentially buy decades of low-cost electricity upfront.

The availability of finance products for farmers will be critical to enabling the sector to invest in CER. As Figure 3 shows, if the upfront capital investment in electric machinery can be financed, farmers can swap inflationary and volatile fossil fuel prices for flat loan repayments. Forest Lodge Orchard saves $40,000 a year on its energy bills. At a 5.5% interest rate, these savings are enough to cover $400,000 of debt over a 15 year loan, or $550,000 at 1% interest. With low-cost finance, farmers can service the debt required to make the upfront investment from the savings on their farm's operating costs.

It's worth noting that the costs of electrifying are coming down rapidly. Forest Lodge Orchard invested in electrification between 2019-2022. Given the fast declining costs of solar and batteries and some electric technology, it is very likely that repeating Forest Lodge Orchard's electrification journey today would cost much less. For example, the orchard plans to triple its capacity for around $180,000. This is about 60% the cost per kWh compared with the current system.

New Zealand delivered energy cost per kWh, historic and forecast.

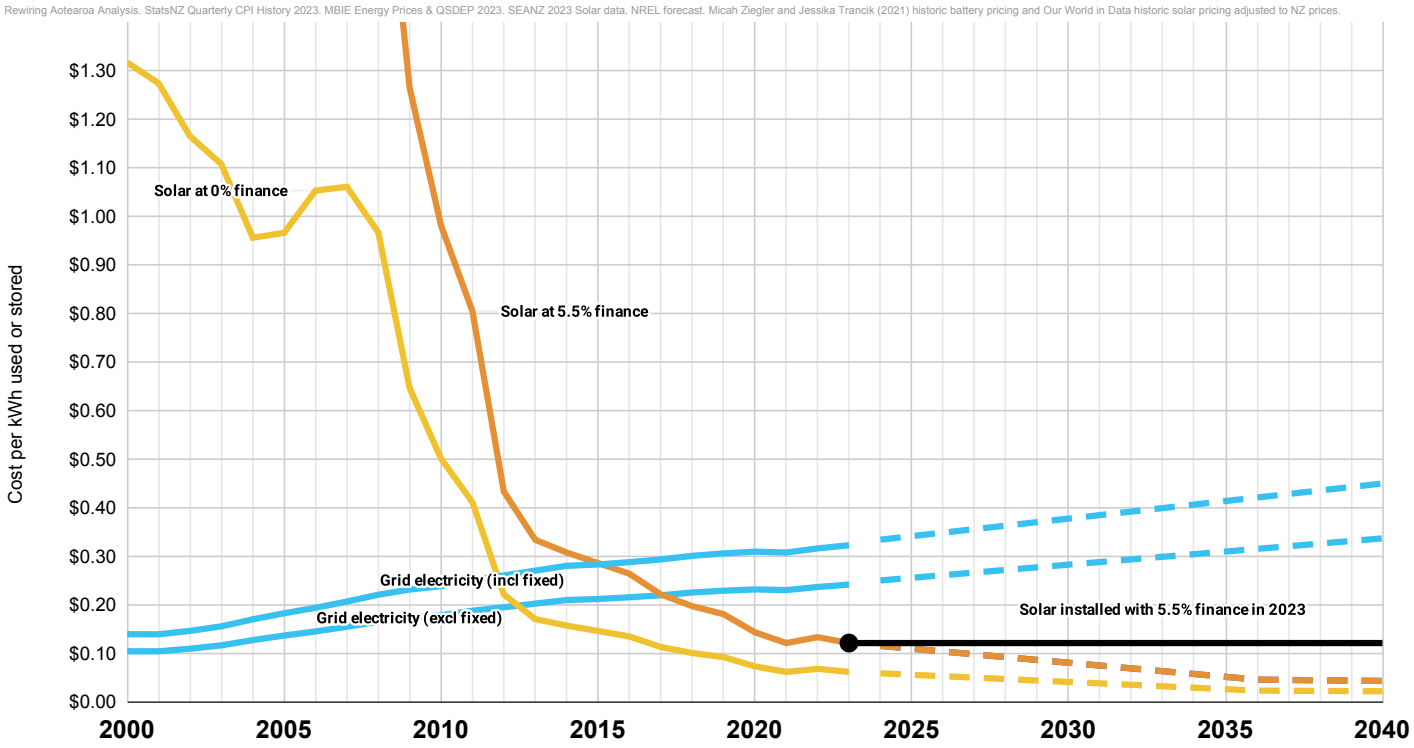


Figure 3. Solar and grid electricity costs compared historically and with future price forecasts. The black line shows the flat repayments for solar financed in 2023 at a fixed interest rate of 5.5%. With rooftop solar and batteries, homes are purchasing many years of energy upfront

Our orchard also has 120kWh of batteries that can be used to support the national grid during peak times. For example, after Transpower's emergency announcement on 10 May warning of a potential shortage of generation on a cold morning, we ensured our batteries were charged up and exported enough electricity to power around 20 homes. If farmers were rewarded fairly for the energy they provide, battery banks like ours would be viable for other farmers, and add significant resilience to the grid.

Resetting the system - what needs to change so farmers can bring down electricity prices for New Zealanders

Through an innovative trial with the local Electricity Distribution Business (EDB), Aurora Energy, at Forest Lodge Orchard we expect to earn about $20,000 of extra revenue by providing power back to the grid. In addition to earning the wholesale rate for electricity exported to the grid during normal times, or at times of high price volatility, the trial will provide larger rewards for Aurora's customers in the Upper Clutha who provide electricity back to the grid during control period demand (CPD) hours. CPD hours are periods of high electricity demand on the Aurora network in Central Otago and the Upper Clutha regions. They usually occur on cold winter mornings, and average around 80 hours per year. During the trial, Aurora will pay Forest Lodge Orchard for our contribution to reducing peak load on the network.

This means in addition to the approximately $8000 a year of revenue from exporting electricity at the wholesale rate, we expect to make another $12,000 from exports during CPD hours. In a year with average CPD hours, our solar and batteries will power 20 homes in Central Otago during CPD periods and receive around $1.50 per kWh. This is the first step in creating an electricity system that rewards farmers for contributing to reduced peak pressures on large-scale generation and distribution.

Total additional profit on Forest Lodge Orchard $60,000

Figure 4. Forest Lodge Orchard makes around $60,000 of additional profit each year through energy cost savings and export back to the grid.

Farms are usually close to medium-voltage electricity networks, so do not suffer the same physical export congestion limits that residential connections have. Farms with mid-scale solar generation and access to medium-voltage networks can usually export as much electricity as their grid connection size allows. This means there are no physical barriers to farms providing large amounts of electricity to support the national grid and help bring down prices for all New Zealanders.

The Aurora trial shows how innovative contracts between EDBs and energy-generating customers can appropriately reward farmers for providing power back to the grid during peak times. To do this nationally, we must update the assumptions in our models on the role that CER can play in the energy system to better reflect its relative costs and potential. We must view generation on farms as part of system infrastructure. The critical point here is that a battery in a farmer's shed should be seen as a competitor to any other electricity supplier and if it is cheaper to access the farmer's energy, then that infrastructure should be prioritised.

The true value mid-scale generation and storage on farms could provide is enormous. Exporting electricity back to the grid can support small-scale microgrids, where *rural communities can build resilience*[1] through local-scale networks and generation, or by feeding into the national grid. For an idea of how impactful this could be, if each of the 50,000 farms in New Zealand installed 500kW of solar capacity, they could generate an additional 28-33,000GWh of electricity each year. This is equal to 63-75% of the country's current total electricity consumption. If each farm also installed 300kWh of batteries, this would add around 9000GWh of additional storage to the grid, and would help address the morning and afternoon peaks. This would take enormous pressure off large-scale generation and would reduce the need for fossil fuel generation from Huntly during dry years.

We believe there could also be potential for farmers to play a role in fulfilling National's promise of rolling out 10,000 EV chargers. Farmers investing in solar and battery systems could not only power their own machines much more affordably and earn money for sending electricity back to the grid at peak times, but they could also become part of an extensive national charging network and create another new revenue stream. There are very little restrictions on network capacity, which has been a problem for rapid charging in urban areas. Many farmers already have large grid connections, especially for powering irrigation pumps.

The growth in irrigation over the last 20 years is one of the major drivers of growth in summer electricity demand, with some parts of the electricity network (e.g., mid-Canterbury) experiencing their highest annual demand in summer. This has led to an increase in fossil fuelled generation over late summer, as hydro operators attempt to store water in their reservoirs for the winter period. An increase in on-farm solar will help reduce the use of coal and gas for summer-based electricity generation and/or alleviate some of the pressure on hydro operators (micro hydro schemes that are non-consumptive, and do not alter the water course of an existing stream or river, and micro wind schemes are also viable alternatives for farmers to generate electricity but this paper has focused on solar and batteries).

Forest Lodge Orchard shows that the time has come for us to change the way we think about our energy systems. There is strong evidence that farms can make massive savings on operating costs through electrification and CER. Although the upfront costs are high, with appropriate finance products the cost savings can be used to pay off the initial investment. In addition, the more farms across the country install solar and battery systems on their properties, the faster the upfront costs will fall.

1. https://www.canterbury.ac.nz/news-and-events/news/are-microgrids-the-answer-to-reliable-power-in-kiwi-homes-

The win-win includes new jobs for rural communities

Installing solar and batteries on New Zealand's farms *would also create thousands of skilled jobs in the regions*.[1] New Zealand currently has about 10,000 new solar setups installed each year. If we were to increase this tenfold to 100,000 per year, we estimate this would add 4,500 solar installation jobs to the industry, not to mention the additional demand for electricians and maintenance workers. The huge upscale in the CER industry in New Zealand would benefit regional economies, creating well paid jobs outside of the main urban centres. Hubs of production and installation would emerge, adding a new layer of economic activity to regional areas.

1. https://www.irena.org/news/pressreleases/2012/Jun/Deployment-of-renewable-energy-creates-access-and-jobs-in-rural-areas

How do we make this happen?

Rolling out the energy system changes we've described here requires a shift in the way we think about our electricity grid to include farms and households as part of system infrastructure. It will take strategic thinking, and a breaking down of biases towards large-scale generation and ingrained paradigms around energy production. But there are some relatively simple initial steps that can be taken to stimulate the market for CER on farms, many of which have already been demonstrated locally or overseas:

1. **Use better models and assumptions to support strategic decision making.** The rate at which costs of CER have come down are such that rooftop solar is now the cheapest source of delivered energy for New Zealanders and the cheapest energy in human history. This must be incorporated into the assumptions we make and the models we use to enable strategic decisions. More realistic assumptions must be used by the Climate Change Commission and MBIE when providing advice or making decisions on New Zealand's energy future.

   We must begin to properly incorporate the potential for CER into energy system planning. This requires the sector to move on from aspirational, national-level estimates of the potential for demand-side involvement, to realistic assessments of what consumer resources exist, or will exist, on their individual networks, and how those resources can be engaged. The work of *Electricity Networks Aotearoa's Future Networks Forum*[1] is critical here. The pan-industry group *FlexForum*[2] has outlined a 39 step plan to re-configure the electricity market and regulatory design to make it easier for homes, farms and businesses to use their onsite flexibility - demand response and solar/battery installations - and be rewarded for it.

2. **Fix the finance.** Finance holds the key to rapid adoption, big savings and significant on-farm emissions reductions. Providing low-cost finance to farmers to de-risk the upfront capital cost of electric machines and CER will make this transition a whole lot more accessible for the sector and ensure it is a sound investment that will unlock a whole new revenue stream for farms. Low-interest 'green loans' are available through the banks for households. How do we make this available to farms? And how could the Government play a role by providing access to funding?

3. **Fairly reward farms for their contribution to the energy system.** Engaging the demand-side of the electricity system in the same way as the sector views large-scale infrastructure will be challenging. It requires the sector to move on from aspirational, national-level estimates of the potential for demand-side involvement, to realistic assessments of what consumer resources exist, or will exist, on their individual networks, and how those resources can be engaged.

   The Government needs to play an active role in shaping the market for CER by incentivising uptake and mandating EDBs to explore opportunities for CER as a tool to ensure any additional investment in large-scale generation is smart. EDBs should be encouraged to innovate as a core part of their asset management and investment planning. This would begin to enable EDBs to think about investment in CER on a level playing field with large-scale infrastructure, which has

1. https://www.ena.org.nz/fnf/
2. http://flexforum.nz

historically been favoured. Feedback tariffs for three phase connections should be mandatory, and other contractual arrangements that provide incentives and proper rewards for consumer investment in CER should be required by EDBs and retailers.

4. **Develop mid-scale products for farmers.** Rooftop solar and battery installations that suit the mid-scale operations we have described should be brought to the market and targeted at farmers. The very high upfront costs of installation must be made manageable through finance options that make this a clearly bankable investment and we believe there is an opportunity for rural retailers to move into this sector.

5. **The Government needs to see electrification as an opportunity to reduce emissions across the country.** Electrification is the low-hanging fruit of emissions reduction for New Zealand. By enabling more New Zealand farms, homes and businesses to electrify without putting undue pressure on the electricity network, installing mid-scale generation and storage on farms will reduce energy emissions in the agriculture sector and across the country. Unlike some other opportunities for decarbonisation, electrification of fossil fuel machines can make a difference right now, while also reducing our dependence on increasingly expensive carbon offsetting. The opportunity presented here means we can decarbonise faster and put downward pressure on energy costs for New Zealanders.

6. **Remove unreasonable restrictions on farmers.** All District Plans should allow mid-scale ground-mounted solar installations as a permitted activity; farms located in an Outstanding Natural Landscape should be allowed to install solar on their roofs and on smaller ground mounted systems; micro-hydro schemes that are non-consumptive should not need a resource consent; and multiple electricity connections on one farm should be able to be grouped together for billing purposes, something known as net metering.

New Zealand has a rich history of electrical innovation. We created the world's first all-electric home, with the world's first practical electric home water heater; the southern hemisphere's first electric public lighting in Reefton; the world's first electric gold dredge; the world's first wet steam geothermal electricity power station; and now the world's first electric fruit farm. Creating the conditions to turn farms into power stations could be the spark we need to ensure New Zealand leads the world again and becomes the most electric agricultural economy.